NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Modulekode:	ITRI626	Metode van aflewering:	Voltyds	Datum:	01/11/2017

Tipe assessering:	Eksamen 1e geleentheid	Vraestelnommer:	1	Sessie:	09:00	Tydsduur:	3 uur

Modulebeskrywing: **Kunsmatige Intelligensie / Artificial Intelligence**	Lokaal: **H309**

Afrolmetode: Rug-aan-Rug

(1) **Gekombineerde** Afrikaans/Engelse vraestel		(2) Vraestel vir 'n **spesifieke taal**			
Aantal studente:	16		Afrikaans	Engels	Ander taal
		Aantal studente:	0	0	0

Benodighede vir vraestel		Aantal per student	**Benodighede** vir vraestel		Aantal per student
Antwoordskrifte	X	2	Multikeuse-kaarte (A5 – 40 vrae)		
Presensiestrokies vir invulvraestel			Multikeuse-kaarte (A4 – 115 vrae)		
Rofwerkpapier			Grafiekpapier		

Is daar 'n **bylaag** aangeheg?	Nee	Indien **Ja** gee 'n kort beskrywing:	

NB: Eksamenafdeling doen geen kontrole wat inhoud of bladsynommers van bylae betref nie.

Sakrekenaars: Nee

Ander hulpmiddels bv. woordeboeke, studiegidse, ens.:		

Inhandiging van antwoordskrifte:	Gewoon
Indien **Per dosent,** lys **Vanne:**	

Eksaminator(e):

(1) **Dr. J. V. (Tiny) du Toit** Bylyn: **992548**

Selfoonnr: Handtekening

Universiteitsnommer: 10789901

(2) Bylyn:

Selfoonnr: Handtekening

Universiteitsnommer:

(3) Bylyn:

Selfoonnr: Handtekening

Universiteitsnommer:

Interne Moderator:

Mnr. H. Foulds Bylyn: **992532**

Selfoonnr: Handtekening

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Eksterne Moderator:

Selfoonnr:

Ingehandig deur:

Dr. J. V. (Tiny) du Toit Universiteitsnommer: 10789901 Bylyn: **992548**

Verwysingsnommer: 7.1.9.3.

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Benodigdhede vir hierdie vraestel/Requirements for this paper:			
Antwoordskrifte/ Answer scripts:	X	Multikeusekaarte (A5)/ Multi-choice cards (A5):	
Presensiestrokies (Invulvraestel)/ Attendance slips (Fill-in paper):		Multikeusekaarte (A4)/ Multi-choice cards (A4):	
Rofwerkpapier/ Scrap paper:		Grafiekpapier/ Graph paper:	

Sakrekenaars/Calculators: **Nee/No**

Ander hulpmiddels/Other resources:

Tipe Assessering/ Type of Assessment:	**Eksamen 1e geleentheid** **Exam 1st opportunity** **Vraestel/Paper 1**	Kwalifikasie/ Qualification:	**B.Sc. Honns**
Modulekode/ Module code:	**ITRI626**	Tydsduur/ Duration:	**3 uur** **3 hour**
Module beskrywing/ Module description:	**Kunsmatige Intelligensie / Artificial Intelligence**	Maks/ Max:	**100**
Eksaminator(e)/ Examiner(s):	**Dr. J. V. (Tiny) du Toit**	Datum/ Date:	**01/11/2017**
Interne/Internal Moderator(s):	**Mnr. H. Foulds**	Tyd/ Time:	**09:00**

Inhandiging van antwoordskrifte/Submission of answer scripts: **Gewoon/Ordinary**

Vraag 1 (Logiese Agente) / *Question 1 (Logical Agents)*

1.1 Gee die vier stappe om enige logiese uitdrukking in Proposisielogika om te skakel na Konjunkte normaalvorm (KNV).

Give the four steps to convert any logical expression in Propositional Logic into Conjunctive normal form (CNF). [10]

Step 1. Eliminate $\Leftrightarrow$, replacing $\alpha \Leftrightarrow \beta$ with $(\alpha \Rightarrow \beta) \wedge (\beta \Rightarrow \alpha)$. (3)

Step 2. Eliminate $\Rightarrow$, replacing $\alpha \Rightarrow \beta$ with $\neg\alpha \vee \beta$. (2)

Step 3. CNF requires $\neg$ to appear only in literals, so we “move $\neg$ inwards” by repeated application of the following equivalences:

$\neg(\neg\alpha) \equiv \alpha$ (double-negation elimination)
$\neg(\alpha \wedge \beta) \equiv (\neg\alpha \vee \neg\beta)$ (De Morgan)
$\neg(\alpha \vee \beta) \equiv (\neg\alpha \wedge \neg\beta)$ (De Morgan) (3)

Step 4. Now we have a sentence containing nested $\wedge$ and $\vee$ operators applied to literals. (2)

1.2 Skakel die volgende logiese uitdrukking om in Konjunkte normaalvorm (KNV). Toon al jou redenasiestappe aan.

Convert the following logical expression into Conjunctive normal form (CNF). Show all you reasoning steps. [12]

¬T ∨ Q ⇒ S ∧ R

¬(¬T ∨ Q) ∨ (S ∧ R) (Eliminate ⇒)
(T ∧ ¬Q) ∨ (S ∧ R) (Move ¬ invards)
(T ∨ (S ∧ R)) ∧ (¬Q ∨ (S ∧ R)) (Distribute ∨ over ∧)
(T ∨ S) ∧ (T ∨ R) ∧ (¬Q ∨ S) ∧ (¬Q ∨ R) (Distribute ∨ over ∧)

Trying something: 4 marks.
Performing the conversion to CNF steps: 6 marks.
Performing the conversion to CNF steps and naming the steps: 12 marks.

1.3 Bepaal of elkeen van die volgende Proposisielogika sinne bevredigbaar, onbevredigbaar of geldig is. Toon all jou redenasiestappe aan.

Determine whether each of the following Propositional Logic sentences is satisfiable, unsatisfiable, or valid. Show all your reasoning steps.

a) Q ∧ True (Bevredigbaar / Satisfiable) – At least one model is true. [3]

Q	True	Q ∧ True
T	T	T
F	T	F

b) (S ⇒ Q) ⇒ ¬S (Bevredigbaar / Satisfiable) – At least one model is true. [5]

S	Q	¬S	S ⇒ Q	(S ⇒ Q) ⇒ ¬S
T	T	F	T	F
T	F	F	F	T
F	T	T	T	T
F	F	T	T	T

c) (P ⇒ S) ⇒ (¬P ∨ S) (Geldig / Valid) – All models are true. [5]

P	S	¬P	(P ⇒ S)	(¬P ∨ S)	(P ⇒ S) ⇒ (¬P ∨ S)
T	T	F	T	T	T
T	F	F	F	F	T
F	T	T	T	T	T
F	F	T	T	T	T

d) P ⋁ Q ⋁ R ⋁ S ⋁ False (Bevredigbaar / Satisfiable) – At least one model is true. [5]

P	Q	R	S	False	P ⋁ Q ⋁ R ⋁ S ⋁ False
T	T	T	T	F	T
T	T	T	F	F	T
T	T	F	T	F	T
T	T	F	F	F	T
T	F	T	T	F	T
T	F	T	F	F	T
T	F	F	T	F	T
T	F	F	F	F	T
F	T	T	T	F	T
F	T	T	F	F	T
F	T	F	T	F	T
F	T	F	F	F	T
F	F	T	T	F	T
F	F	T	F	F	T
F	F	F	T	F	T
F	F	F	F	F	F

Vraag 2 (Eerste-orde Logika) / *Question 2 (First-Order Logic)*

2.1 Skryf die volgende Engelse sinne oor in Eerste-orde Logika. / *Rewrite the following English sentences into First-Order Logic.* [20]

a) All students who take AI like to play games.

∀s Student(s) ∧ Takes(s,AI) → Likes(s,Games) (4)

b) No students who take AI like to play games.

¬(∃s Student(s) ∧ Takes(s,AI) ∧ Likes(s,Games)) (4)

which is equivalent to:

∀s ¬Student(s) ∨ ¬Takes(s,AI) ∨ ¬Likes(s,Games)

and to:

∀s (Student(s) ∧ Takes(s,AI)) → ¬Likes(s,Games)

c) On Saturday, all students either go to a party or work, but not both.

Using Sat for Saturday, we have:

∀s Student(s) ∧ (Work(s, Sat) ∧ ¬Party(s, Sat)) ∨ (¬Work(s, Sat) ∧ Party(s, Sat)) (4)

d) All students go to a party on Saturday, except those taking AI.

∀s Student(s) ∧ ¬Takes(s, AI) → Party(s, Sat) (4)

e) Exactly two students go to a party on Saturday.

∃x, y Student(x) ∧ Student(y) ∧ Party(x, Sat) ∧ Party(y, Sat) ∧ ¬(x = y) ∧ (∀z (¬(z = x) ∧ ¬(z = y)) → ¬Party(z, Sat)) (4)

Vraag 3 (Inferensie met Eerste-orde Logika) / *Question 3 (Inference in First-Order Logic)*

3.1 Deur van voorwaardse skakeling gebruik te maak, bewys die volgende. Toon al jou redenasiestappe aan.

By using forward chaining, proof the following. Show all your reasoning steps.

KB = All cats like fish, cats eat everything they like, and Ziggy is a cat.

Goal query: Does Ziggy eat fish? [20]

Convert the KB and goal query to First-Order Logic sentences:

1) $\forall x\ Cat(x) \Rightarrow Likes(x, Fish)$
2) $\forall x\ \forall y\ Cat(x) \wedge Likes(x, y) \Rightarrow Eats(x, y)$
3) $Cat(Ziggy)$

Goal query: $Eats(Ziggy, Fish)$ (4 x 2 = 8)

Convert the KB and goal query to First-Order definite clauses:

1) $Cat(x) \Rightarrow Likes(x, Fish)$
2) $Cat(x) \wedge Likes(x, y) \Rightarrow Eats(x, y)$
3) $Cat(Ziggy)$

Goal query: $Eats(Ziggy, Fish)$ (6)

Perform forward chaining:

Modus ponens applied to (1) and (3) with $\theta = \{x / Ziggy\}$ gives

4) $Likes(Ziggy, Fish)$ (3)

Modus ponens applied to (2), (3) and (4) with $\theta = \{x / Ziggy, y / Fish\}$ gives

5) $Eats(Ziggy, Fish)$ (3)

This proves that Ziggy does indeed eat fish.

3.2 Deur van die Resolusie algoritme gebruik te maak, bewys die volgende. Toon al jou redenasiestappe aan.

By using the Resolution algorithm, proof the following. Show all your reasoning steps. [20]

$Mother(Lulu, Fifi)$
$Alive(Lulu)$
$\forall x\ \forall y\ Mother(x,y) \Rightarrow Parent(x,y)$
$\forall x\ \forall y\ (Parent(x,y) \wedge Alive(x)) \Rightarrow Older(x,y)$

Goal query: $Older(Lulu, Fifi)$

Add the negation of the goal query to the knowledge base:

$Mother(Lulu, Fifi)$
$Alive(Lulu)$
$\forall x\ \forall y\ Mother(x,y) \Rightarrow Parent(x,y)$
$\forall x\ \forall y\ (Parent(x,y) \wedge Alive(x)) \Rightarrow Older(x,y)$
$\neg Older(Lulu, Fifi)$ (2)

Convert the knowledge base and negation of the goal query to Conjunctive normal form (CNF):

1) $Mother(Lulu, Fifi)$
2) $Alive(Lulu)$
3) $\neg Mother(x,y) \vee Parent(x,y)$
4) $\neg Parent(x,y) \vee \neg Alive(x) \vee Older(x,y)$
5) $\neg Older(Lulu, Fifi)$ (5 x 2 = 10)

Apply the Resolution rule repeatedly until the empty clause (□) is obtained or until no further deductions can be made.

Resolution between (1) and (3) with θ = {x / Lulu, y / Fifi} gives

6) Parent(Lulu, Fifi)

Resolution between (6) and (4) with θ = {x / Lulu, y / Fifi} gives

7) ¬Alive(Lulu) ∨ Older(Lulu, Fifi)

Resolution between (7) and (2) gives

8) Older(Lulu, Fifi)

Resolution between (8) and (5) gives

9) □ (6)

This proves a contradiction and consequently, Older(Lulu, Fifi) is true. Thus, KB ⊨ Older(Lulu, Fifi) (2)

TOTAAL/TOTAL: 100

Verwysingsnommer: 8.1.7.2.2